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(E73-10971) THE INFLUENCE OF IMAGE POSITION ON URBAN PLACE DETECTION (Kansas Univ. Center for Research, Inc.) 9 p HC $3.00 CSCL 08B

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CENTER FOR RESEARCH, INC.
UNIVERSITY OF KANSAS

ERTS DETAILED IMAGE INTERPRETATION REPORT

CRINC DIIR No. 2262-3

Date Prepared 14 Jan 73

Subject:

The Influence of Image Position on Urban Place Detection

Subject Geographic Coordinates 37-19N 95-09W

NASA Test Site No. N/A

NASA Image Descriptors:

City

Report Summary: The ability of ERTS MSS imagery to detect small urban places appears to vary with the position of the place in the image, as well as from band to band. Urban places of smallest size (~ 2,000 population) seem more detectable in the westernmost 3.5° scan segment. A relationship may exist between shadowing of vertical features and detectability.

Imagery References

CRINC Image No.	NASA Image ID Block	Subject Image Coordinates X	Y	Cloud Cover	Image Quality
MP00432	E-1002-16303-4	(9.5) 93	85	10%	Fair
MP00433	E-1002-16303-5	(9.5) 93	85	10%	Good
MP00434	E-1002-16303-6	(9.5) 93	85	10%	Fair
MP00435	E-1002-16303-7	(9.5) 93	85	10%	Good
MP00292	E-1095-16454-4	(9.5) 98	86	0%	Good
MP00294	E-1095-16454-5	(9.5) 98	86	0%	Good
MP00293	E-1095-16454-6	(9.5) 98	86	0%	Good
MP00295	E-1095-16454-7	(9.5) 98	86	0%	Good

Map References:
USGS NJ 15-7 1:250,000
USAF, ONC G-20 1:1,000,000

Digital Data Used Yes ___ No x

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REPORT

Numerous small urban places exist in southeastern Kansas and southwestern Missouri. The towns vary in size from hamlets to small cities of 40,000 population. The purpose of this analysis was to determine a cut-off limit in terms of population size below which no further detection of urban places could be made in the ERTS image. The preliminary interpretation revealed that for this region, no central place smaller than approximately 2,000 persons could be identified. However, for towns greater than 2,000, a great deal of variability in their detection existed not only from MSS band to MSS band, but also from one relative location in the image to another.

The apparent relationship between position within the image and detectability of a given size town was further analyzed by the following method:

A) All 26 towns greater than 2,000 population were identified on an ONC chart.

B) A classification scheme was developed which assigned each town on each MSS band image to one of the following categories:

1. The town is detectable without prior knowledge of its location.
2. The town is detectable only with prior knowledge of its location (i.e., known map location).
3. The town is detectable only by use of surrogate information from the image (i.e., known map location plus known physiographic features).
4. The town is not detectable on the image.

C) All 26 towns were interpreted from the images assigned to one of the categories and the results recorded (Table 1).

After completion of the interpretation outlined above, the detectability data for each town was arranged according to population, but failed to reveal a single population size above which the towns were detectable. However, when the data set was partitioned into four sectors to correspond to scan angle segments of 3.25° (Table 2 and Figure 1), it revealed greater detectability for smaller places (2,000 to 5,000 population) in the westernmost 3.25° scan segment with decreasing detection eastward. This decreasing detectability eastward across the image can also be seen from the fact that Yates Center (population 2,096) is easily detectable in both bands 4 and 5 in the western image section, while Pittsburg (population 20,373) in the east center image segment is not detectable without map information in any band.

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Further analysis reveals that when the diagonal bisector of the image is drawn, the more detectable towns lie northwest of the line while the least detectable towns lie southeast. Given the sun elevation of 59° and azimuth of 116°, the diagonal bisector describes the point of change westward of which the sensor images the "sunny" side of vertically developed objects, while eastward of the bisector the sensor images the shadow side of the vertically developed objects. To determine if this effect is generally influencing detectability, another image set for central Kansas was subjected to the same interpretation as had been performed on the southeastern Kansas set. The results (Figure 2 and Table 3) show increased detectability for small urban places throughout the image. This image set reveals less noticeable variations in detection as a function of image location than the southeastern Kansas images; however, detection is highest in longer wavelength bands, the reverse of the southeastern Kansas case. This may be due to several interacting variables which are too complex to model holoistically but include sun angle, energy path lengths, target position, scattering properties of the target, and sensor properties, i.e., instantaneous scan angle.

One possible explanation for the variation in detectability across the image is related to shadowing of vertically developed objects. Such shadowing would be most pronounced in areas with vertical components which are not closely spaced and of varying heights, i.e., urban places and woodlands (Williams, 1973).

The causes of such variation along a scan line may be illustrated by the following simplified example. Assume a block 1m square by 10m tall located on a flat surface. This block is illuminated from an infinite distance source (parallel rays) with an elevation of 59° above the plane and an azimuth of 116°. This elevation causes a shadow approximately 6m long. The illumination cross section of the block is the block's diagonal (1.14m in this case). Therefore, the shadow area is 8.46m^2. The north and west faces of the block are not illuminated, whereas the south and east faces are. The block is oriented so that the north-south axis is parallel to the sensor flight path. The minimum square with the same flight path orientation and large enough to include the block and its shadow is 5.8m on a side. If this 5.8m square is considered to be the sensor resolution cell size, the following conditions will prevail at nadir and maximum scanner angles for ERTS.

At the nadir position, 25% of the resolution cell continuing the block is shadow (theoretically, matte black) and the vertical reflecting faces of the block are parallel to the sensor (do not contribute to the return). If the block is located at the west end of the scan line, angular displacement due to vertical development displaces the top of the block 1.14m to the west. The consequence of this displacement is to expose part of the face of the block and to conceal part of the shadow, resulting in reduction of the proportion of shadow to 20% of the resolution cell and increased exposure of the vertical face to direct reflectance. If the block is located at the east end of the scan line, the same displacement occurs, but of the shadowed rather than the illuminated face of the block. This results in an increase in the proportion of shadow to 30% of the resolution cell and to non-exposure of the vertical face to direct reflectance.

Although this model is greatly simplified, the process of changing shadow proportions appears to contribute to variations in detectability of similar sized towns. This process may be enhanced or diminished by the site and situation of the town.

Direct cost of this project was 16 hours interpreter time and 4 hours drafting time.

REFERENCE

Williams, Donald L. 1973. Tonal variations of woodlands in southeastern Kansas as a function of within-image location. Center for Research, Inc. AIR No. 2262-1.

Table 1. Detectability of urban places on ERTS-1 imagery. Detectability is recorded according to the image sector in which the place is located. Numbers in the table indicate detectability, with 1 indicating the most detectable and 4 indicating nondetectability.

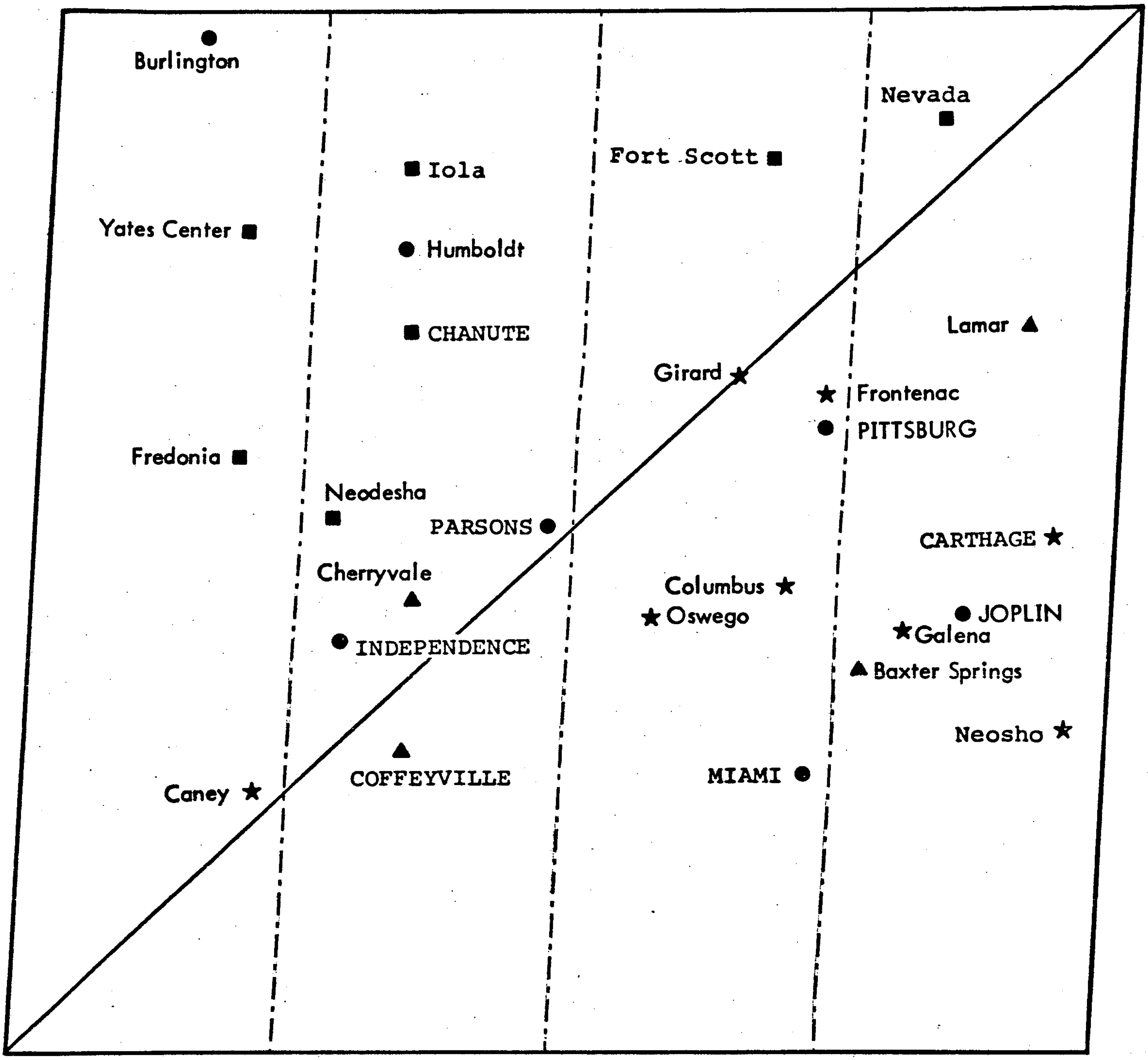
		Band 4 Sector				Band 5 Sector				Band 6 Sector				Band 7 Sector			
Town	Population	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Joplin	38,424				2				3				4				2
Pittsburg	20,373			4				3				4				2	
Coffeyville	17,374		3				3				4				3		
Miami	13,801			2				3				4				3	
Parsons	12,031		2				3				4				2		
Independence	11,594		3				2				4				4		
Carthage	11,043				4				4				4				4
Chanute	10,182		1				1					3				1	
Nevada	9,516				1				3				4				3
Fort Scott	8,767			1				1				4				3	
Neosho	7,570				4				4				4				4
Iola	6,658		1				1				3				2		
Baxter Springs	4,797				4				4				4				4
Lamar	3,720				3				3				4				4
Neodesha	3,657		1				2				4				4		
Fredonia	3,574	1				2				4				3			
Columbus	3,531			4				4				4				4	
Galena	3,464				3				4				4				4
Cherryvale	2,907		3				4				4				4		
Girard	2,791			4				4				4				4	
Caney	2,750	4				4				4				4			
Frontenac	2,412			4				4				4				4	
Humboldt	2,308		3				2				4				3		
Burlington	2,297	3				3				4				2			
Oswego	2,126			4				4				4				4	
Yates Center	2,096	2				1				4				3			

Table 2. Maximum detectability of urban places based on population and image sector. Detectability is reported in this table without regard to which band was used.

	Sector			
Town	1	2	3	4
Joplin				2
Pittsburg			2	
Coffeyville		3		
Miami			2	
Parsons		2		
Independence		2		
Carthage				4
Chanute		1		
Nevada				1
Fort Scott			1	
Neosho				4
Iola		1		
Baxter Springs				4
Lamar				3
Neodesha		1		
Fredonia	1			
Columbus			4	
Galena				3
Cherryvale		3		
Girard			4	
Caney	4			
Frontenac			4	
Humboldt		2		
Burlington	2			
Oswego			4	
Yates Center	1			

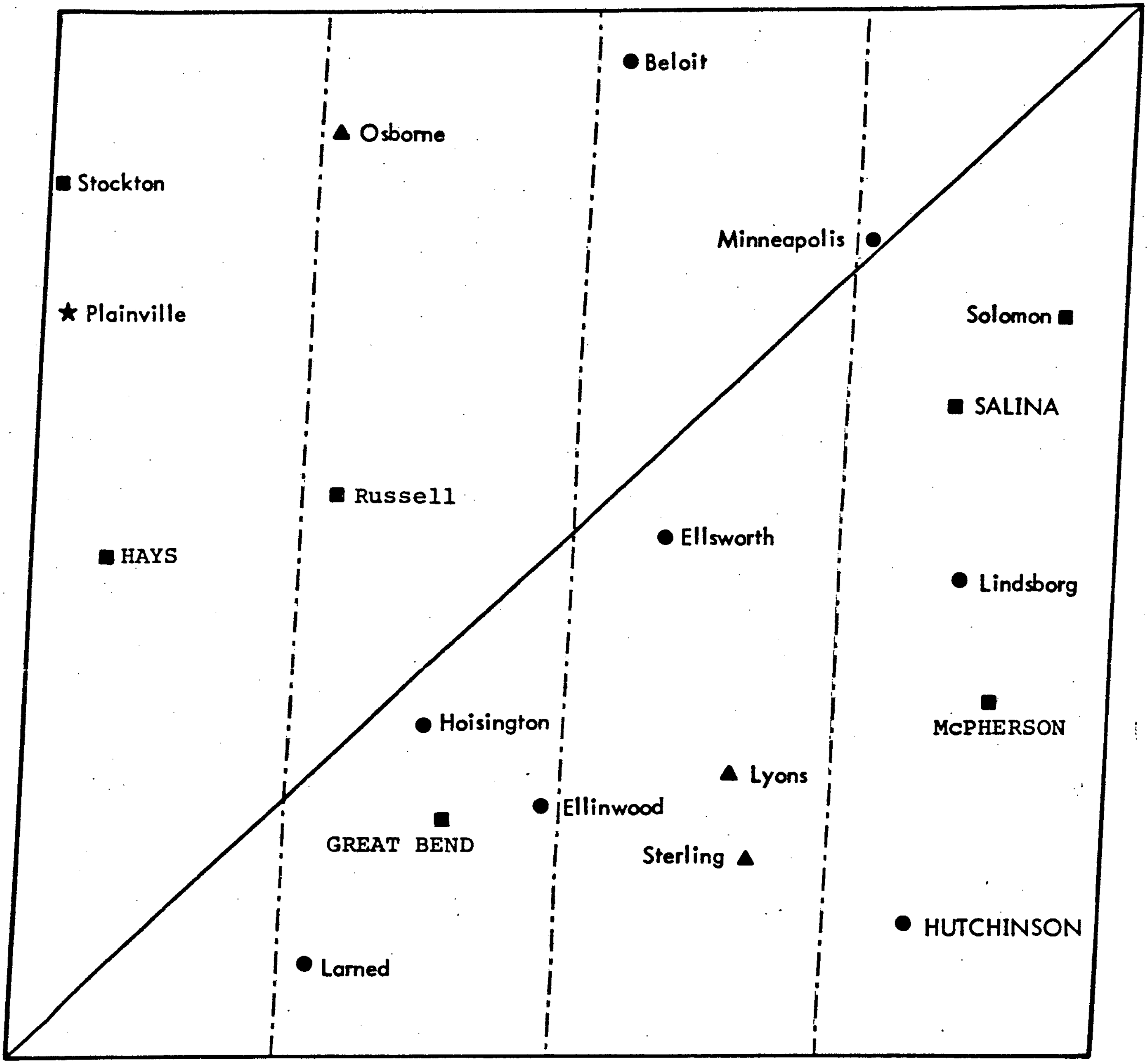
Table 3. Maximum detectability of urban places in central Kansas, based on population and image sector. Detectability is reported in this table without regard to which band was used.

Town	Population	Sector 1	2	3	4
Hutchinson	41,823	1			2
Salina	36,609				1
Great Bend	18,497		1		
Hays	15,270	1			
McPherson	10,578				1
Russell	5,516		1		
Larned	4,830		2		
Lyons	4,537			3	
Hoisington	4,459		2		
Beloit	4,003			2	
Ellinwood	2,826		2		
Plainville	2,639	4			
Ellsworth	2,442			2	
Minneapolis	2,086				2
Osborne	2,064		3		
Lindsborg	2,051				2
Sterling	1,964			3	
Stockton	1,834	1			
Solomon	1,192				1



Population		Detectability	
2,000-5,000	Oswego	1	■
5,000-10,000	Iola	2	●
10,000-20,000	CARTHAGE	3	▲
20,000-50,000	JOPLIN	4	★

Figure 1. Towns in southeastern Kansas and adjacent areas of Missouri and Oklahoma, shown according to population and detectability from ERTS-1 imagery.



Population		Detectability	
1,000-5,000	Larned	1	■
5,000-10,000	Russell	2	●
10,000-20,000	GREAT BEND	3	▲
20,000-50,000	SALINA	4	★

Figure 2. Towns in central Kansas, shown according to population and detectability from ERTS-1 imagery.